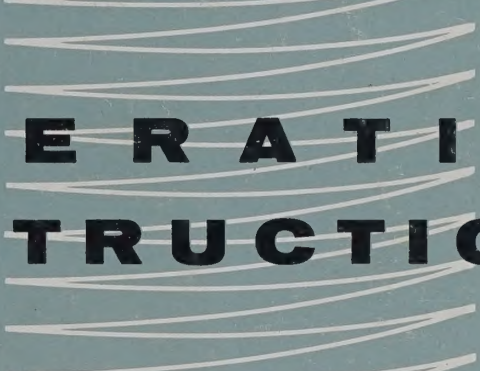




BRUSH

O P E R A T I N G I N S T R U C T I O N S



DUAL CHANNEL D. C. AMPLIFIERS
MODELS RD 5621 00, RD 5621 01, and RD 5621 02





Model RD 5621 00, RD 5621 01, and RD 5621 02

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DUAL CHANNEL D. C. AMPLIFIERS MODELS RD 5621 00, RD 5621 01, and RD 5621 02

This instruction book applies to

Model RD 5621 00 Serial No.

Model RD 5621 01 Serial No.

Model RD 5621 02 Serial No.

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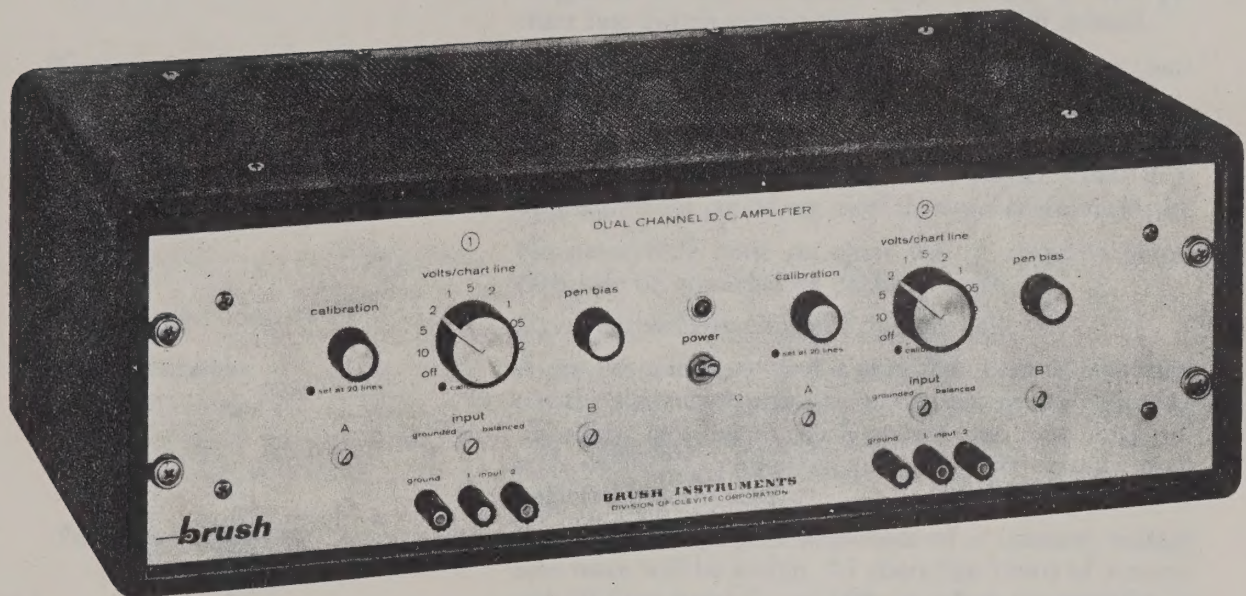
1. Notify the nearest factory branch service station, address on the next page, giving full details of the difficulty, and include the model number, type number and serial number. Upon receipt of this information, we will give you service instructions or issue a material return authorization card.

2. You may request any necessary instrument pack-

aging by telling us what cartons you need. These will be sent to you no charge.

3. Upon receipt of shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

**DUAL CHANNEL D. C. AMPLIFIERS
MODELS RD 5621 00, RD 5621 01, and RD 5621 02**



Dual Channel D.C. Amplifier Model RD 5621 01.

The Brush Dual Channel D.C. Amplifiers Models RD 5621 00, RD 5621 01, and RD 5621 02 provide two independent channels of amplification, accepting input signals up to 400 volts peak to peak. Models RD 5621 00 and RD 5621 01 are capable, at maximum sensitivity, of deflecting a Brush oscillograph pen 1 mm with an amplifier input signal of 10 millivolts, with a drift of no more than $\frac{1}{2}$ mm per hour (when Brush chart paper is used). The Model RD 5621 02, at maximum sensitivity, will deflect a Brush oscillograph pen 1 mm with an amplifier input signal of 50 millivolts, with a drift of no more than $\frac{1}{10}$ mm per hour.

SPECIFICATIONS**MODEL RD 5621 00**

Sensitivity with Brush oscillograph...	10 millivolts per chart line (mm). Full scale deflection from chart center ± 200 millivolts.
Sensitivity steps.....	.01, .02, .05, .1, .2, .5, 1, 2, 5, and 10 volts per chart line (mm). Maximum attenuator error 1% with balanced input.
Measurement range with Brush oscillograph	
Single-ended input (5 megohm)	.010 volt to 400 volts.
Balanced input (10 megohm)....	.010 volt to 400 volts, side to side, allowable voltage off-ground at any attenuator step is 1000 x volts per chart line switch setting up to 500 volts off ground.
Common mode rejection.....	Better than 1000 to 1, attenuator set in .01 volt per chart line position.
Amplifier zero line stability.....	$\frac{1}{2}$ chart line (mm) per hour, or less, when used with a Brush oscillograph and Brush chart paper. Total drift over eight hour period not more than one chart line (mm).
Noise	No perceptible noise on chart with 1 megohm across each side of grounded or balanced input.
Calibration	Signal derived from internal mercury cell.
Signal expander.....	A pen positioning control is provided. Permits balancing out the static component of a complex signal, deflecting the signal zero line as much as 200 lines (ten times full scale deflection) either side of chart center except when balanced input is used.
Frequency response.....	Recorded peak-to-peak amplitude of a constant voltage sine wave will be within ± 1 chart line (mm) of a nominal 10 lines from d.c. to 100 cps when the amplifier is compensated with a Brush oscillograph.
Output impedance.....	Approximately 50 ohms.
Maximum output current.....	± 20 milliamperes into 1500 ohms.
Input power required.....	105-125 volts, 60 cps, $\pm \frac{1}{2}$ cps; 90 watts at 115 volts.
Power cable	2 wire attached cord. 3 wire attached cord available on special order.
Tubes	4-12AT7, 2-12AX7, 4-5687, and 1-12BW4.
Dimensions	
Standard panel.....	19" wide x 5 $\frac{1}{4}$ " high x $\frac{1}{4}$ " thick.
Depth.....	10 $\frac{3}{4}$ " (with connectors 12 $\frac{1}{2}$ ").
Net weight.....	24 pounds.
Shipping weight.....	30 pounds.
Signal input terminals	
Front.....	Binding posts.
Rear.....	Two 3 pin male AN type. (Matching connectors supplied.)
Output terminals.....	Two 6 pin female AN type (cable to connect amplifier to Brush RD series oscillographs supplied).

MODEL RD 5621 01

Sensitivity with Brush oscillograph ..	10 millivolts per chart line (mm). Full scale deflection from chart center ± 200 millivolts.
Sensitivity steps	.01, .02, .05, .1, .2, .5, 1, 2, 5, and 10 volts per chart line (mm). Maximum attenuator error 1% with balanced input.
Measurement range with Brush oscillograph	
Single-ended input (5 megohm) ..	.010 volt to 400 volts.
Balanced input (10 megohm)	.010 volt to 400 volts, side to side, allowable voltage off-ground at any attenuator step is 1000 x volts per chart line switch setting up to 500 volts off ground.
Common mode rejection	Better than 1000 to 1, attenuator set in .01 volt per chart line position.
Amplifier zero line stability	$\frac{1}{2}$ chart line (mm) per hour, or less, when used with a Brush oscillograph and Brush chart paper. Total drift over eight hour period not more than one chart line (mm).
Noise	No perceptible noise on chart with 1 megohm across each side of grounded or balanced input.
Calibration	Signal derived from internal mercury cell.
Signal expander	A pen positioning control is provided. Permits balancing out the static component of a complex signal, deflecting the signal zero line as much as 200 lines (ten times full scale deflection) either side of chart center except when balanced input is used.
Frequency response	Recorded peak-to-peak amplitude of a constant voltage sine wave will be within ± 1 chart line (mm) of a nominal 10 lines from d.c. to 100 cps when the amplifier is compensated with a Brush oscillograph.
Output impedance	Approximately 50 ohms.
Maximum output current	± 20 milliamperes into 1500 ohms.
Input power required	105 to 125 volts (or 95 to 115 volts), 50 to 2000 cps; 85 watts at 115 volts, 60 cps.
Power cable	2 wire attached cord. 3 wire attached cord available on special order.
Tubes	4-12AT7, 3-12AX7, 4-5687, 1-6BW4, 1-6080, and 1-6626/OA2WA.
Dimensions	
Standard panel	19" wide x $5\frac{1}{4}$ " high x $\frac{1}{4}$ " thick.
Depth	$10\frac{3}{4}$ " (with connectors $12\frac{1}{2}$ ").
Net weight	20 pounds.
Shipping weight	26 pounds.
Signal input terminals	
Front	Binding posts.
Rear	Two 3 pin male AN type. (Matching connectors supplied.)
Output terminals	Two 6 pin female AN type (cable to connect amplifier to Brush RD series oscillographs supplied).

MODEL RD 5621 02

Sensitivity with Brush oscillograph ..	50 millivolts per chart line (mm). Full scale deflection from chart center ± 1.0 volt.
Sensitivity steps.....	.05, .1, .2, .5, 1, 2, 5, and 10 volts per chart line (mm). Maximum attenuator error 1% with balanced input.
Measurement range with Brush oscillograph	
Single-ended input (5 megohm)	.050 volt to 400 volts.
Balanced input (10 megohm)....	.050 volt to 400 volts, side to side, allowable voltage off-ground at any attenuator step is 1000 x volts per chart line switch setting up to 500 volts off ground.
Common mode rejection.....	Better than 1000 to 1, attenuator set in .05 volt per chart line position.
Amplifier zero line stability.....	1/10 chart line (mm) per hour, or less, when used with a Brush oscillograph and Brush chart paper. Total drift over eight hour period not more than $\frac{1}{4}$ chart line (mm).
Noise.....	No perceptible noise on chart with 1 megohm across each side of grounded or balanced input.
Calibration.....	Signal derived from internal mercury cell.
Signal expander.....	A pen positioning control is provided. Permits balancing out the static component of a complex signal, deflecting the signal zero line as much as 200 lines (ten times full scale deflection) either side of chart center except when balanced input is used.
Frequency response.....	Recorded peak-to-peak amplitude of a constant voltage sine wave will be within ± 1 chart line (mm) of a nominal 10 lines from d.c. to 100 cps when the amplifier is compensated with a Brush oscillograph.
Output impedance.....	Approximately 50 ohms.
Maximum output current.....	± 20 milliamperes into 1500 ohms.
Input power required.....	105 to 125 volts (or 95 to 115 volts), 50 to 2000 cps; 85 watts at 115 volts, 60 cps.
Power cable.....	2 wire attached cord. 3 wire attached cord available on special order.
Tubes.....	4-12AT7, 3-12AX7, 4-5687, 1-6BW4, 1-6080, and 1-6626/OA2WA.
Dimensions	
Standard panel.....	19" wide x 5 $\frac{1}{4}$ " high x $\frac{1}{4}$ " thick.
Depth.....	10 $\frac{3}{4}$ " (with connectors 12 $\frac{1}{2}$ ").
Net weight.....	20 pounds.
Shipping weight.....	26 pounds.
Signal input terminals	
Front.....	Binding posts.
Rear.....	Two 3 pin male AN type. (Matching connectors supplied.)
Output terminals.....	Two 6 pin female AN type (cable to connect amplifier to Brush RD series oscillographs supplied).

Remove the amplifier and all accessory items from the carton. See that all items in the packing list (below) are included in the shipment. Examine the instrument and accessory items for damage. For procedure to be followed if damage is noted, refer to "Claim for Damage in Shipment" following the Table of Contents.

PACKING LIST

When the Dual Channel D.C. Amplifier is ordered as part of a matched recording system, only those items necessary for connection and use of the amplifier with other instruments in the system are included in the shipment.

The following items are included when the amplifier alone is purchased:

1. Two amplifier-to-oscillograph signal cables, Part No. 223385-501.
2. Two signal input connectors (3 pin female, AN type), Part No. 121275.
3. Two cable clamps (for 3 pin connectors), Part No. 119993-104.

INSTALLING THE INSTRUMENT IN RACK OR PORTABLE CASE

The Dual Channel D.C. Amplifier may be installed in a standard 19" rack or in the Brush Portable Case Model RA 1105 30. For rack mounting, the amplifier may be mounted in the Brush RA 1152 60 Rack, which is designed to accommodate six 5¼" high amplifiers and one RD 2662 00 series oscillograph. The rack includes a blower and duct for adequate ventilation of the system. If the Brush RA 1152 60 Rack is not used, ventilation must be provided for proper operation of the amplifier and associated equipment. Adequate ventilation is important to the proper operation of electronic equipment and components.

To install the amplifier in a standard 19" rack, position the instrument in the rack, secure the front panel to the rack rails with four screws, and connect external cables at the front or rear of the amplifier.

In applications where maximum portability is desired, the Brush Portable Case Model RA 1105 30 is recommended. The case, finished in grey wrinkle enamel, is 20⅛" wide, 6⅜" high, and 10⅜" deep; it is designed to accommodate any of the Brush line of rack-mounted instruments built on the standard 19" panel, 5¼" high, and ¼" thick. Although extremely rigid, the case is light in weight (8 pounds, 5 ounces). A recessed strap-type carrying handle increases its portability. A number of Portable Cases may be stacked vertically, affording some of the advantages of rack mounting without detracting from the portability of the individual amplifiers. The amplifier may be ordered with a 3 conductor power cable for portable applications.

When the Amplifier and Portable Case are purchased together, the Amplifier is installed in the case at the factory. To install the Amplifier in the Brush Portable Case Model RA 1105 30, proceed as follows:

1. Remove both the top and bottom sections of the wrap-around cover of the instrument to be case mounted.
2. Stand the case on its back.
3. Place the four sheet spring nuts over the four holes in the recessed portion of the front of the case.
4. Slip the chassis into the case.
5. Lift one end of the case slightly to align the holes through the bottom with the corresponding threaded holes in the chassis. Start (but do not tighten) two pan head machine screws (#8-32 $\times$ 1" long) at bottom rear of the case.
6. Mount the four rubber feet on four pan head machine screws (#8-32 $\times$ 1 1/8" long).
7. Start (but do not tighten) the screws with the rubber feet, first in one end of the bottom of the case, and then in the other.
8. Start (but do not tighten) six pan head machine screws (#8-32 $\times$ 1" long) through the top of the case and into the amplifier chassis.
9. Insert and tighten the four oval head, cross recessed, self tapping type "A" screws, with countersunk trim washers and nylon grommets, through the front panel and into the case.
10. Tighten all screws in the top and bottom of the case.

PREPARATION FOR USE

USE WITH OSCILLOGRAPHS

The Brush Dual Channel D.C. Amplifier is designed to be used with Brush "RD" series oscillographs. It may be used with Brush "BL" series oscillographs, but frequency response and sensitivity will differ from the values noted under "Specifications." The Dual Channel D.C. Amplifier must be grounded adequately, either to a grounded rack or a grounded conduit.

"RD" series amplifiers and oscillographs are frequency compensated at the factory when purchased together. If they are purchased separately, the amplifier frequency compensation may be adjusted as described below under "Frequency Compensation."

CONNECTING AMPLIFIER TO OSCILLOGRAPH

The output terminals of this amplifier are 30 volts (d.c.) above chassis, and should not be connected to any load in which either terminal is grounded. To connect amplifier to an oscillograph, proceed as follows:

1. See that the amplifier and oscillograph are disconnected from their power source, and that power switches of the amplifier and oscillograph are in "off" position.
2. Connect the amplifier OUTPUT connector (Fig. 1), on the back of the amplifier, to the oscillograph input connector with the cable supplied.

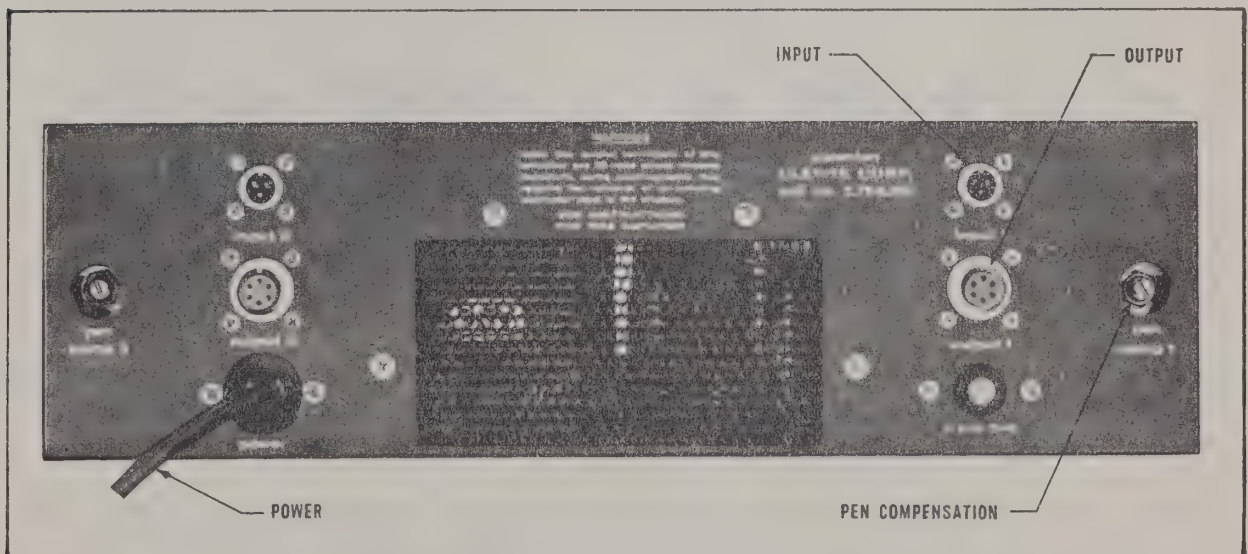


Fig. 1. Rear Panel —Dual Channel D.C. Amplifier.

CONNECTING AMPLIFIER AND OSCILLOGRAPH TO POWER SOURCE

1. Refer to the operating instructions for the oscillograph, and connect the oscillograph to its power source. Test the oscillograph for proper operation, and turn the oscillograph power switch "off".

2. Connect the amplifier power cable (Fig. 1) to a 115 volt power source. (The Model RD 5621 00 will accept only a 60 cps power input, while Models RD 5621 01 and RD 5621 02 will accept a 50 to 2000 cps power input.)

CALIBRATION AND TESTING

The Dual Channel D.C. Amplifier is balanced at the factory and, if the amplifier is purchased with an oscillograph, the amplifier is frequency compensated to that oscillograph. Balancing procedures described below are necessary only when new tubes are installed in the instrument, or when operation of the CALIBRATION control (Fig. 2) causes pen to shift. Frequency compensation procedures described below are necessary only when the amplifier is used with an oscillograph other than the one with which it was purchased. For routine operation, omit balancing and frequency compensation procedures and continue with "Calibration", below.

BALANCING

The amplifier should be balanced after connection of the amplifier and oscillograph to their power source. To balance either channel of the amplifier, proceed as follows:

1. Turn *both* VOLTS/CHART LINE switches (Fig. 2) to "off". Turn the amplifier POWER switch (Fig. 2) to "on" and allow 15 minutes for the amplifier to warm up.

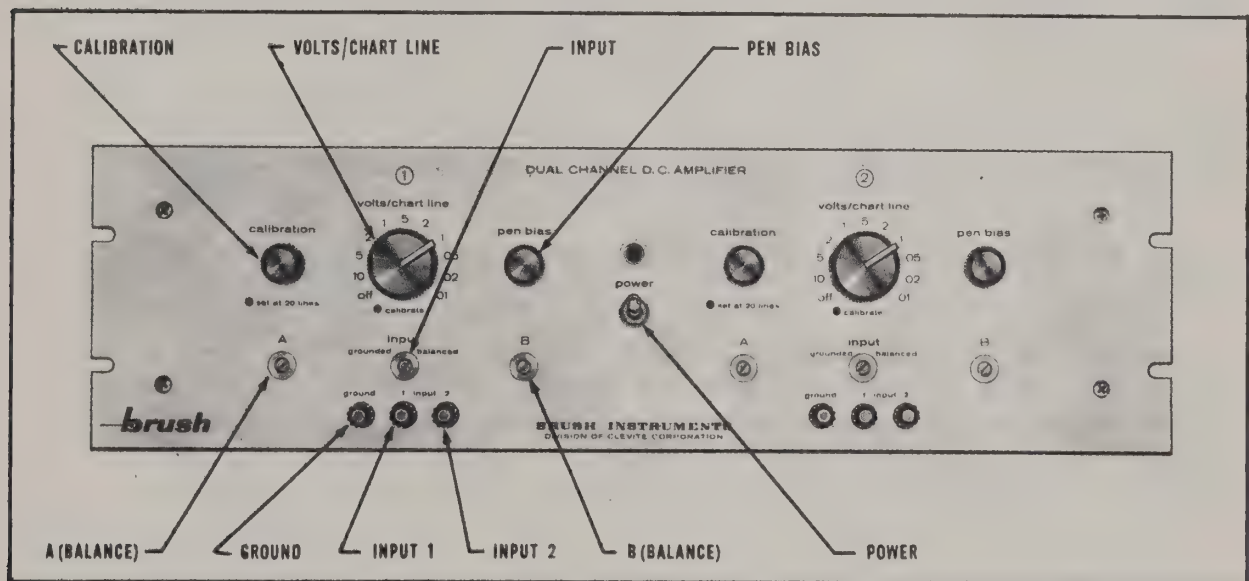


Fig. 2. Front Panel Controls and Connectors—Dual Channel D.C. Amplifier Model RD 5621 01.

2. Turn the oscillograph "on" at slow chart paper speed (to conserve chart paper), and set the INPUT switch (Fig. 2) in the "balanced" position.
3. Turn the CALIBRATION control (Fig. 2) full clockwise, and bring the oscillograph pen approximately to chart center by means of the B-(BALANCE) control (Fig. 2).
4. Turn the A (BALANCE) control (Fig. 2) to its extreme counterclockwise position. Rapidly rotate the CALIBRATION control (Fig. 2), counterclockwise, then clockwise, while turning the A (BALANCE) control slowly clockwise until no pen deflection is noted.
5. Center the pen on the chart by means of the B (BALANCE) control (Fig. 2), and turn the oscillograph "off".

FREQUENCY COMPENSATION

To obtain optimum frequency response of a Brush amplifier-oscillograph combination, the frequency response of the amplifier must be adjusted to match the penmotor of the oscillograph. (When an amplifier and an oscillograph are purchased as a matched system, this adjustment is made at the factory. If the instruments are purchased separately and if frequencies over 30 cps are to be recorded, the frequency compensation procedure must be observed.) When the amplifier is used with a Brush oscillograph and flat response to high frequencies is not required, the PEN COMPENSATION control (Fig. 1) may be turned "off" (fully counterclockwise).

To match either Channel 1 or Channel 2 of the amplifier to an oscillograph, balance the amplifier channel as described under "Balancing", above, and proceed as follows:

1. Connect an oscillator covering the range from 10 to 100 cps to the INPUT 1 terminal (Fig. 2) and the INPUT 2 terminal (Fig. 2) on the front panel of the amplifier. If the corresponding INPUT connector (Fig. 1) on the rear panel is used, connect the oscillator to pin "A" (ground) and pin "C". To reduce hum pickup it is recommended that shielded leads be used.
2. Set the INPUT switch (Fig. 2) in the "grounded" position. When the INPUT switch (Fig. 2) is in the "grounded" position, the INPUT 1 terminal is shorted to ground, allowing connections to be made at the INPUT 1 and INPUT 2 terminals.
3. Turn the oscillograph "on". Set the VOLTS/CHART LINE switch (Fig. 2) in the "10" position and, with the oscillograph operating at a chart paper speed of 20 or 25 mm/sec, center the oscillograph pen trace on the chart paper by means of the PEN BIAS control (Fig. 2).
4. Turn the oscillograph "on". Set the PEN COMPENSATION control (Fig. 1) in approximately mid-position.
5. Adjust oscillator output level at 10 cps for 10 lines total pen deflection (peak-to-peak). If oscillator output is not sufficient to produce 10 lines pen deflection, turn the VOLTS/CHART LINE switch to a more sensitive position to produce 10 lines of deflection. It may be necessary to increase or decrease the oscillator output voltage, or to change the setting of the CALIBRATION control (Fig. 2) to obtain the desired 10 line deflection.

The oscillator output voltage is a reference voltage and must be held constant during the frequency compensation procedure; the settings of the oscillator output voltage control, the VOLTS/CHART LINE switch (Fig. 2), and the CALIBRATION control (Fig. 2) must remain unchanged.

6. At 100 cps (with oscillator output voltage the same as in step 5, above), adjust the PEN COMPENSATION control (Fig. 1) as necessary to obtain a pen deflection of 10 chart lines.
7. Sweep the frequency range from 10 cps to 100 cps (holding oscillator output voltage constant) and check for flatness of response. Adjust the PEN COMPENSATION control (Fig. 1), if necessary, to obtain optimum response from 10 cps to 100 cps. Turn the oscillograph "off".

CALIBRATION

After matching amplifier channels with their respective penmotors (see "Frequency Compensation," above), calibrate the amplifier as follows:

1. Turn the VOLTS/CHART LINE switch (Fig. 2) "off" and set the INPUT switch (Fig. 2) in the "balanced" position. If the oscillograph pen is not on the center line of the chart, repeat the "Balancing" procedure described above.
2. Turn the VOLTS/CHART LINE switch (Fig. 2) to the "calibrate" position and adjust the CALIBRATION control (Fig. 2) as necessary to obtain a pen deflection of 20 chart lines left of center. Turn the VOLTS/CHART LINE switch to "off".
3. Check 20 line deflection by again turning the VOLTS/CHART LINE switch (Fig. 2) to the "calibrate" position. If necessary, readjust the CALIBRATION control (Fig. 2) to obtain a pen deflection of 20 chart lines.

PRELIMINARY OPERATION

Connect the amplifier to a signal source of known amplitude by means of the GROUND, INPUT 1, and INPUT 2 terminals (Fig. 2) on the front panel, or by means of the INPUT connector (Fig. 1) on the rear panel, using shielded leads when the impedance of the signal source is high.

When connecting a single-ended input at the front panel, connect the "hot" side (in reference to ground) to the INPUT 2 terminal (Fig. 2). Connect the side of the signal to be grounded to the GROUND terminal (Fig. 2) or the INPUT 1 terminal (Fig. 2).

When connecting a single-ended input at the rear panel, connect the "hot" side of the signal to pin "C" of the INPUT connector (Fig. 1), and connect the side of the signal to be grounded to pin "B" or pin "A". When the INPUT switch (Fig. 2) is in the "grounded" position, pin "B" is shorted to pin "A", so that either pin may be used as a ground connection.

To connect a balanced input at the front panel, connect one side of the input circuit to the INPUT 1 terminal (Fig. 2), and the other side to the INPUT 2 terminal (Fig. 2). To connect a balanced input at the rear panel, connect one side of the input circuit to pin "B" of the INPUT connector (Fig. 1), and connect the other side to pin "C". The ground point of the signal source, if available, as well as signal cable shielding should be connected to the GROUND terminal (Fig. 2) on the front panel, or to pin "A" of the INPUT connector on the rear panel.

OPERATION

WARNING

Because the chassis is common to both amplifier circuits, check the circuitry of the signals being recorded to see whether or not the common amplifier circuit will prevent satisfactory recording.

Each channel of the Dual Channel D.C. amplifier is separate and complete, except for the common power supply and chassis circuit. For this reason, the operating procedures described below will consider only one channel unless otherwise noted. The information applies to either Channel 1 or Channel 2 of the amplifier, and the channels may be operated separately or simultaneously. To operate either channel of the amplifier, proceed as described below.

SINGLE-ENDED AND BALANCED INPUT SIGNALS

Each channel will accept either single-ended or "balanced" input signals. A single-ended signal is obtained from a circuit having one terminal already at ground potential, or a circuit which will not be disturbed if one terminal is connected to ground or to the amplifier chassis.

A "balanced" or double-ended signal, as used in connection with the Dual Channel D.C. Amplifier, is a signal obtained from a circuit which will be disturbed when one terminal is connected to ground. For example, the voltage across the secondary winding of a transformer with an intermediate tap connected to ground may be defined as a "balanced", or double-ended signal. Grounding either output terminal of such a circuit would short circuit the transformer.

When one side of the signal circuit is connected to ground a considerable distance from the amplifier input and the signal level is low, it is possible that "ground currents" through the "ground" connection to the amplifier will produce sufficient voltage drop between the signal source and the amplifier to introduce spurious signals. In such a case it is advisable to use the "balanced" input terminals, ("INPUT 1" and "INPUT 2") with one terminal connected to ground at the signal source as shown in Figure 3, and with the INPUT switch in the "balanced" position. Such connections eliminate the "ground loop" in the input circuit.

Figure 4 shows connection of single-ended signals to both channels of the amplifier for simultaneous recording of related information. In this case it is desired to measure voltage across an a.c. lamp, and to measure the output of a photoelectric cell at the same time. Channel 1 receives a single-ended signal from the a.c. lamp with one side of the signal grounded. Channel 2 receives a single-ended signal, representing the output of the photoelectric cell; one side of the single-ended signal is grounded through shielding. In this circuit, the

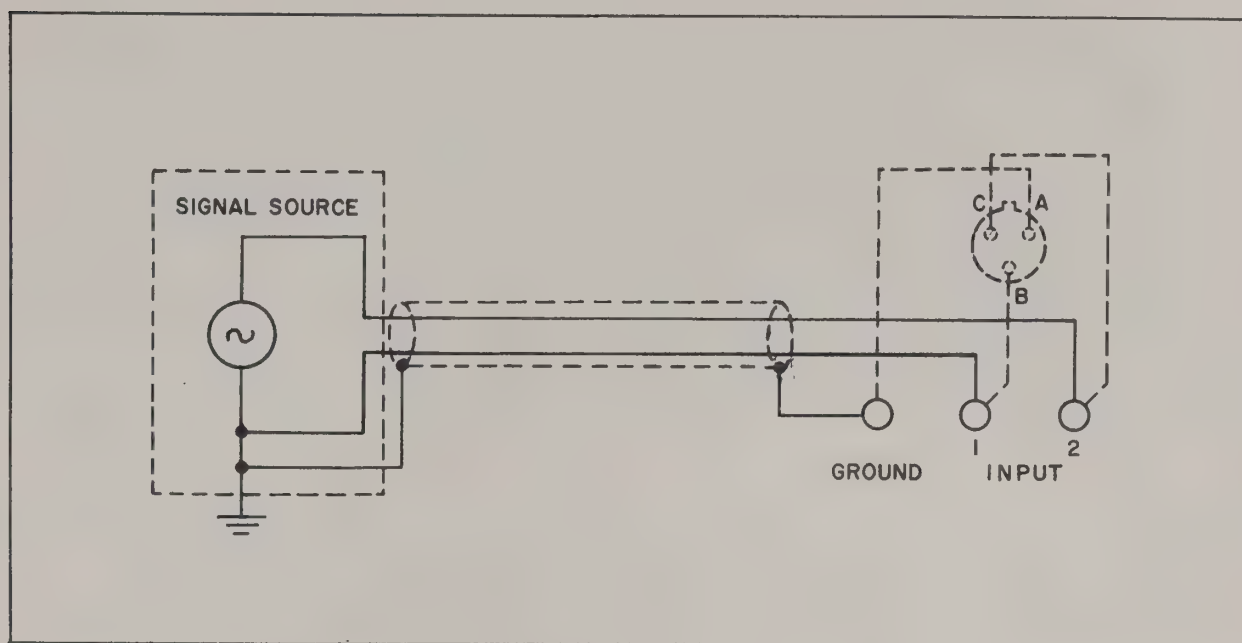


Fig. 3. Connection of Single-Ended Input from Remote Signal Source.

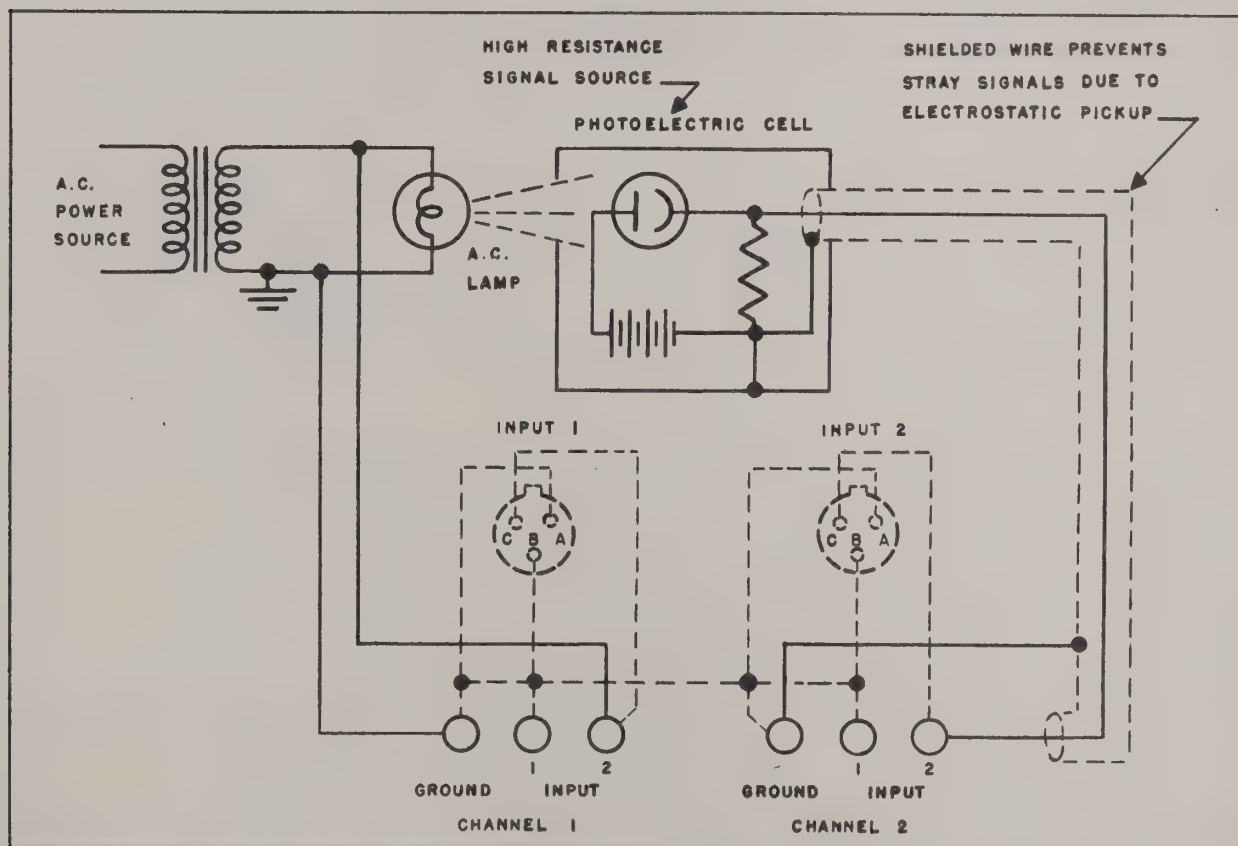


Fig. 4. Typical Connection of Single-Ended Inputs to Channel 1 and Channel 2
—One Side of Input to Channel 2 Grounded Through Shielding.

"GROUND" and "INPUT 1" terminals of the two channels are connected internally to a common ground, and both INPUT switches are in the "grounded" position.

Often, during the simultaneous recording of related information, a "balanced" signal must be connected to one channel of the amplifier, while a single-ended signal is connected to the other channel. Figure 5 illustrates such an application of the Dual Channel D.C. Amplifier. Channel 1 is used to measure a single-ended signal representing the voltage across a relay coil. Channel 2 is used to measure a "balanced" signal representing the voltage across a load connected to the secondary leads from a transformer. In this case the INPUT switch of Channel 1 is in the "grounded" position, so that the GROUND and INPUT 1 terminals are connected, while the INPUT switch of Channel 2 is in the "balanced" position. The unused GROUND terminal of Channel 2 is connected internally to the GROUND and INPUT 1 terminals of Channel 1.

NORMAL OPERATION

1. Turn the VOLTS/CHART LINE switch (Fig. 2) successively to a more sensitive position, "5", "2", etc., to reach the desired sensitivity. The signal voltage is equal to the number of lines of pen deflection, from the signal zero position, multiplied by the setting of the VOLTS/CHART LINE switch.
2. Adjust the oscillograph pen to the desired position on the chart paper by means of the PEN BIAS control (Fig. 2) if the INPUT switch (Fig. 2) is in the "grounded" position. No adjustment can be made if the INPUT switch is in the "balanced" position. See "Calibration", above.

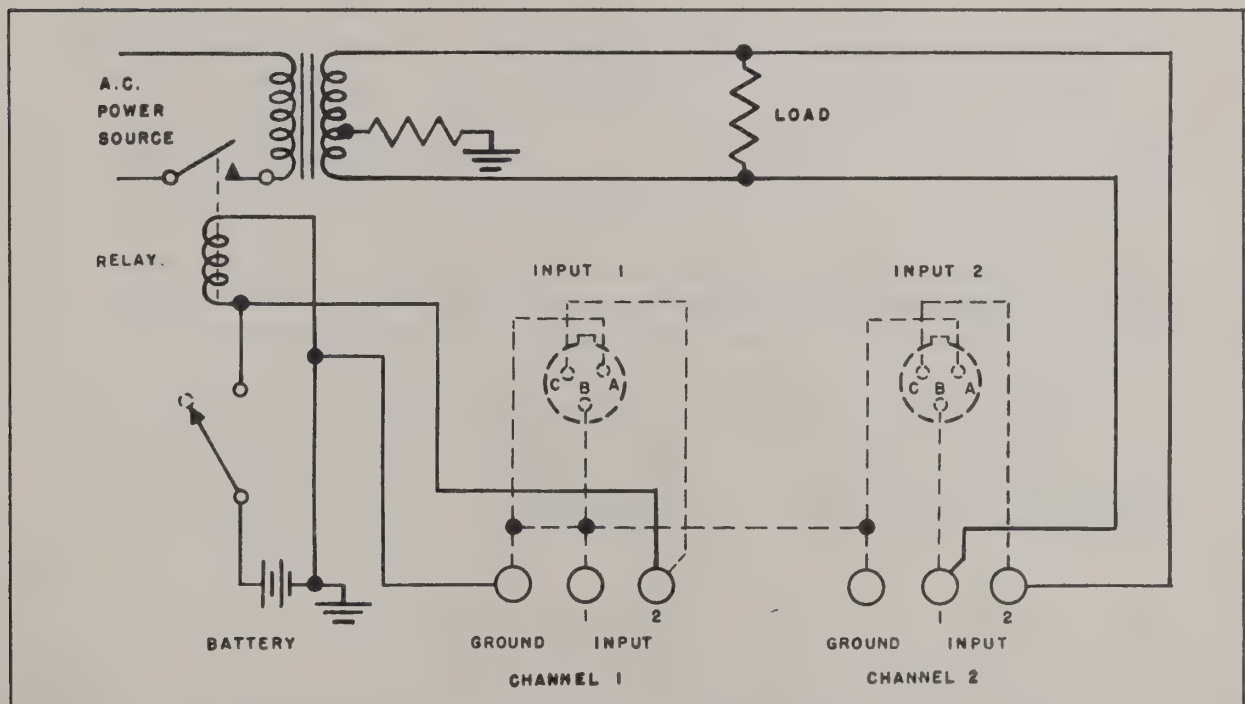


Fig. 5. Typical Connection of Single-Ended Input to Channel 1, "Balanced" Input to Channel 2.

OFF-CENTER ZERO OPERATION

(When using single-ended input only)

It is often desirable to expand the recording of a small dynamic signal superimposed on a larger d.c. voltage for close examination. In such cases, the PEN BIAS control (Fig. 2) may be used, in conjunction with the VOLTS/CHART LINE switch (Fig. 2), for electrical displacement of the pen zero reference position as much as 200 lines either side of chart center. (Such signal expansion is possible only when a single-ended input is used.)

To expand the dynamic portion of a complex signal for more convenient study, proceed as follows:

1. Calibrate the recording system as described above. The CALIBRATION, or gain control (Fig. 2), once set, should not be moved during the study of the dynamic signal.
2. With the VOLTS/CHART LINE switch (Fig. 2) in the "10" position, center the oscillograph pen on the chart paper by means of the PEN BIAS control (Fig. 2).
3. Turn the VOLTS/CHART LINE switch (Fig. 2) to "5", "2", "1", etc., until a satisfactory pen deflection is noted.
4. Note the number of lines of pen deflection representing the static component of the complex signal, where

$$\text{VOLTS/CHART LINE SWITCH SETTING} \times \text{AVERAGE PEN DEFLECTION} = \text{STATIC COMPONENT OF SIGNAL VOLTAGE.}$$

5. Using the PEN BIAS control (Fig. 2), move the recording of the dynamic signal across chart center to the opposite edge of the chart.
6. Repeat steps 3 and 5, above, until the recording of the dynamic signal can no longer be moved across chart center by operation of the PEN BIAS control (Fig. 2). Maximum accuracy of recording will be obtained when the dynamic signal is centered on the chart.
7. The amplitude of the dynamic component can then be determined by the formula

$$\text{VOLTS/CHART LINE SWITCH SETTING} \times \text{DYNAMIC PEN DEFLECTION} = \text{DYNAMIC COMPONENT OF SIGNAL VOLTAGE.}$$

The Dual Channel D.C. Amplifier consists of two d.c. amplifier channels operated from a common power supply (Fig. 6). The input circuit of each amplifier channel provides selection of single-ended or balanced input signals, attenuation of signal voltages, and application of calibration or pen bias voltages. The d.c. amplifier section in each channel amplifies input signals to the level required for driving an oscillograph penmotor. The output circuit carries amplified signals to the penmotor, applies negative feedback to stabilize overall gain in the amplifier section, and provides adjustment of amplifier frequency response to produce optimum response in the amplifier-oscillograph combination.

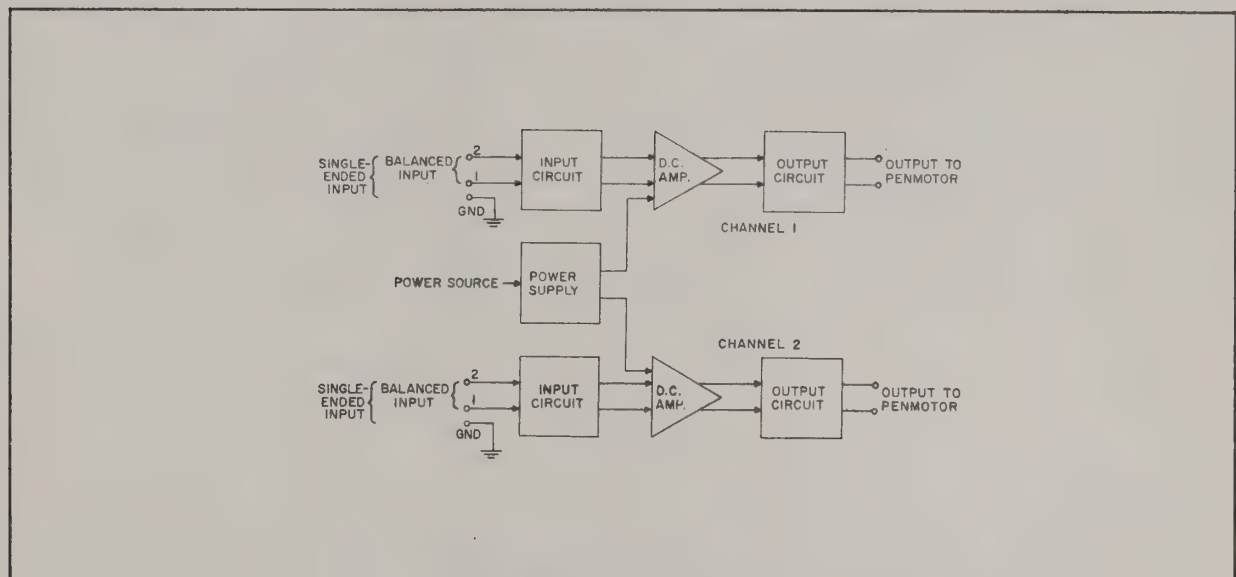


Fig. 6. Block Diagram—Dual Channel D.C. Amplifier.

D. C. AMPLIFIER SECTION

INPUT CIRCUIT

The constant resistance attenuator in the input circuit (Figs. 7 and 8) provides the means of varying the input level to the first stage of the amplifier circuit. This attenuator always presents a 5 megohm resistance to a single-ended signal source, or a 10 megohm resistance to a balanced signal source throughout the attenuator range. At the first position of the VOLTS/CHART LINE switch (.01 volt per millimeter for Models RD 5621 00 and RD 5621 01, .05 volt per millimeter for the Model RD 5621 02) the input signal is not attenuated, and the sensitivity of the amplifier circuit is the same as during calibration.

For single-ended ("grounded") operation, input signals are coupled to the amplifier between the INPUT 2 terminal and the GROUND or INPUT 1 terminal. In this case, half of the attenuator is used to couple signals to one grid of the input tube (V-1). A pen bias signal, derived from two mercury cells in the Model RD 5621 00, derived from a voltage

D.C. AMPLIFIER CIRCUIT

The input stage of the pen drive amplifier circuit (Fig. 9) consists of a high gain dual triode (V-1) used as a differential d.c. amplifier. The input signal applied to this stage may include an in-phase component and a differential component. The in-phase component, applied to both input grids of V-1 at the same amplitude and polarity, is an unwanted signal. Under this condition the input circuit operates as two parallel amplifiers with high cathode degeneration; accordingly, the gain of the in-phase component is effectively reduced in the input stage. The desired differential component of the input signal is applied between the two input grids of V-1 with opposite polarities. Since the signal currents flowing through the common cathode resistor are of opposite polarities, no degeneration occurs at that point. As a result, differential voltage gain is not reduced in the first stage.

Gain is controlled by the relatively small "uncommon" cathode degeneration resistance. Variation of this resistance with the calibration potentiometer varies degeneration, and thus controls gain of the input stage. If the two tube halves of the input stage are not perfectly balanced, variation of the gain control will produce, in effect, a differential input signal, which is undesirable. Such an effect is eliminated by the "balance" potentiometer adjustment, which provides compensation for tube unbalance. At the plate circuits of the input stage, output voltages are summed with feedback voltages from the amplifier output circuit, and coupled to succeeding amplifier stages.

The second and third stages of the pen drive amplifier channel consist of two high gain dual triodes (V-2, V-3) used as conventional direct-coupled differential amplifiers. A balance control is provided in the second stage, to permit further compensation for tube unbalance in the last three stages of the amplifier channel.

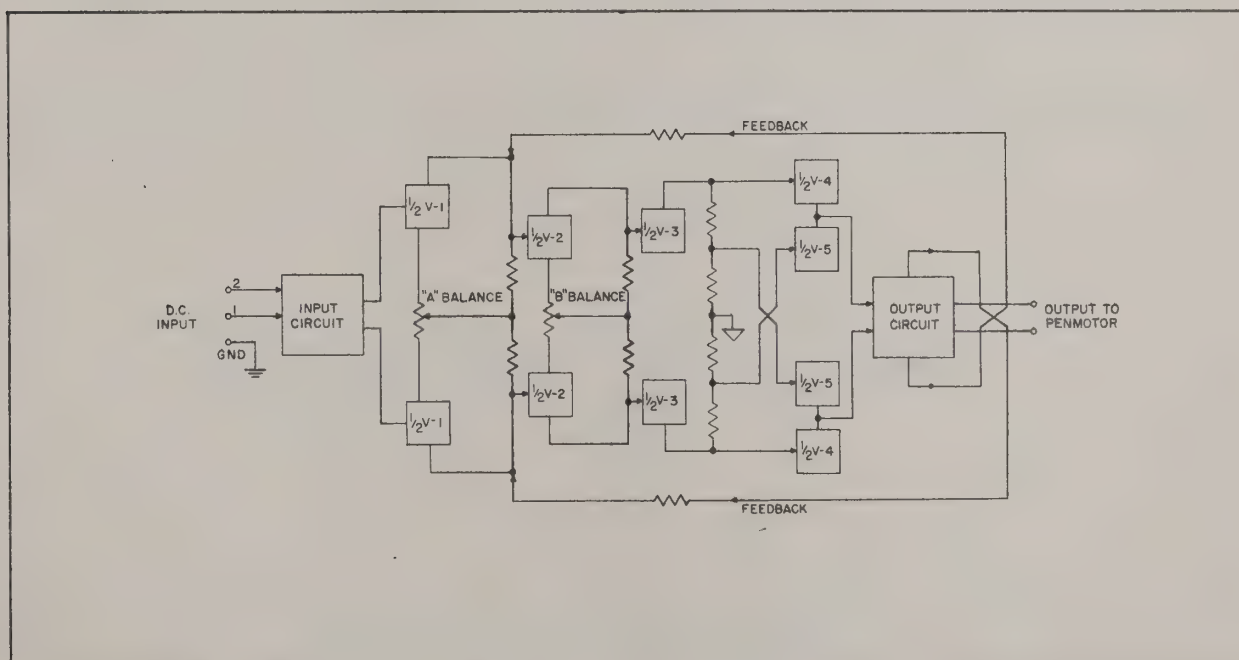


Fig. 9. D.C. Amplifier Circuit.

The third stage tube (V-3) is coupled to a pair of medium gain dual triodes (V-4, V-5), which operate as a bridge output circuit. The sections of each output tube appear at opposite arms of the bridge, so that the penmotor coil is, in effect, the load across the bridge. The signals which appear at the input grids of the bridge circuit are equal in amplitude, but opposite in polarity. A voltage divider applies a portion of each bridge input signal to one tube section. This tube section and the tube section receiving the full input signal are on opposite arms of the bridge circuit. (For example, if the full bridge input signal is applied to a grid of V-4, a portion of this same signal is applied to a grid of V-5, on the opposite arm of the bridge circuit.) Application of input voltages to the bridge circuit provides a low impedance series current path through the two tube sections to which positive voltages are applied, and through the penmotor. This causes deflection of the oscillograph pen. Reversing polarity of the input voltages produces a current path through the other two tube sections and through the penmotor. Because the direction of current flow through the penmotor coil has been reversed by the change in polarity of the input signals, the pen is now deflected in the opposite direction.

OUTPUT CIRCUIT

Negative feedback paths from the output terminals of the bridge circuit to the summing points in the plate circuits of the input tube (V-1) provide approximately 26 db of d.c. feedback to stabilize overall gain in the amplifier channel (Fig. 10). The a.c. negative feedback around these paths may be reduced with increasing frequency by two capacitors connected across the feedback networks. Compensation of the frequency response of the amplifier to match that of the penmotor is accomplished by varying the effect of one of these capacitors, through the use of a dual potentiometer in the feedback network. A switch is provided on this dual potentiometer to disconnect the two capacitors across the feedback networks.

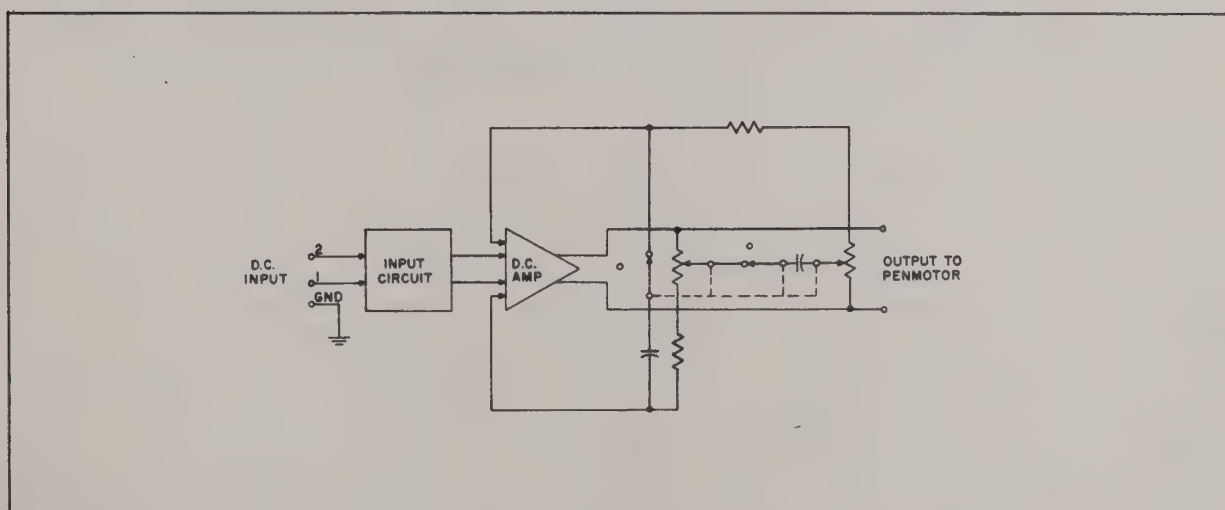


Fig. 10. Output Circuit—Dual Channel D.C. Amplifier.

POWER SUPPLY

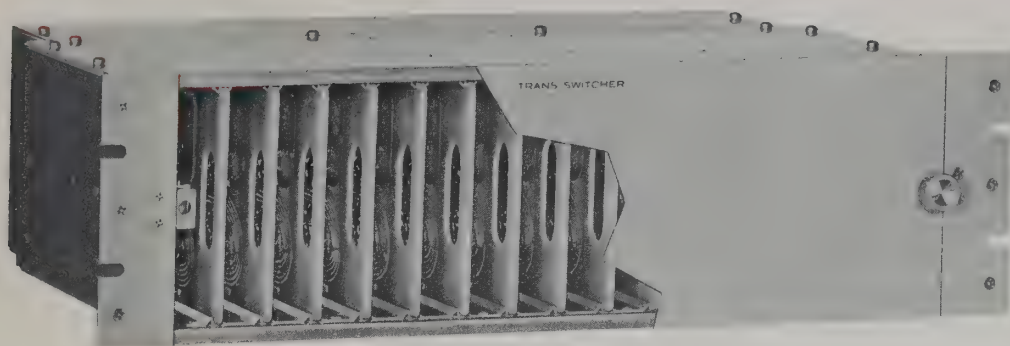
MODEL RD 5621 00

A double-ended type power supply is provided for operation of the pen drive amplifier circuits in the Dual Channel D.C. Amplifier Model RD 5621 00. This power supply depends on regulation obtained from a constant voltage type transformer which supplies both plate and filament voltages. Plate supply voltage regulation is maintained to 1%; tube filament voltages, also obtained from the constant voltage transformer, are regulated to 3%.

MODELS RD 5621 01 AND RD 5621 02

An electronically-regulated power supply with a wide frequency range is used in the Dual Channel D.C. Amplifiers Models RD 5621 01 and RD 5621 02, permitting operation from power lines in the frequency range of from 50 to 2000 cps. The power supply provides series-type regulation for plate voltage, and also provides an a.c. filament voltage. High voltage from the transformer (T-1) is rectified in a 6BW4 tube (V-6) and applied to the plates of the 6080 series regulator tube (V-7). (The load is connected to the cathodes of the series regulator tube.) This output voltage is compared at the grid (Pin 7) of the 12AX7 tube (V-8) with voltage from a 6626/OA2WA reference tube (V-9). This comparison determines whether or not the output voltage of the +B supply agrees with the desired voltage, as preset on the potentiometer (R-79). If not, a voltage change proportional to the error appears at the plate (Pin 6) of the 12AX7 tube. This voltage is amplified by the other section of the 12AX7 tube and applied as a bias voltage to the 6080 series regulator tube. This correcting action is continuous, regulating the output voltage of the power supply for varying conditions of load and input voltage.

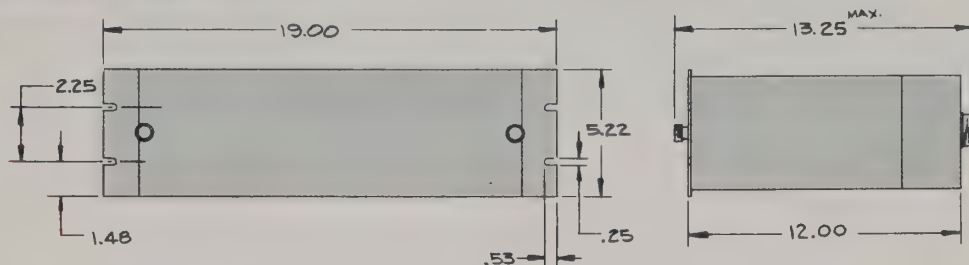
The +B output of the power supply is connected to the -B output by a voltage divider (R-85, R-86, R-87, and R-88), which establishes the potential from -B to chassis ground for operation of the double-ended amplifier system. This voltage divider also provides pen bias voltage used for positioning the oscillograph pen. Filament voltages for the amplifier system are derived from transformers T-1 and T-2. An interference filter, located at the power input of the power supply, minimizes the effect of any transients present in the power line.



RA 3402 10
for positive signals

RA 3402 20
for negative signals

NEW

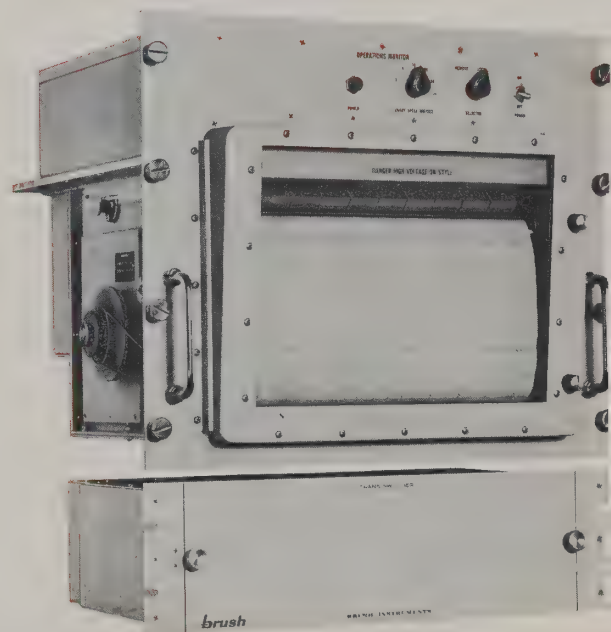


Up to 120 separate Trans-Switcher circuits plus a specified power supply are contained in this rack-mounting enclosure, which occupies only 5 1/4" of panel space. Plug-in receptacles for Trans-Switcher decade boards allow quick interchange, boards are easily accessible, all necessary connectors are supplied. No rewiring is required when shifting to different modes of signal input and recording.

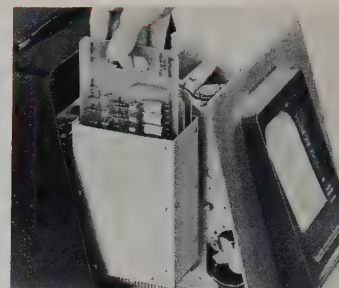
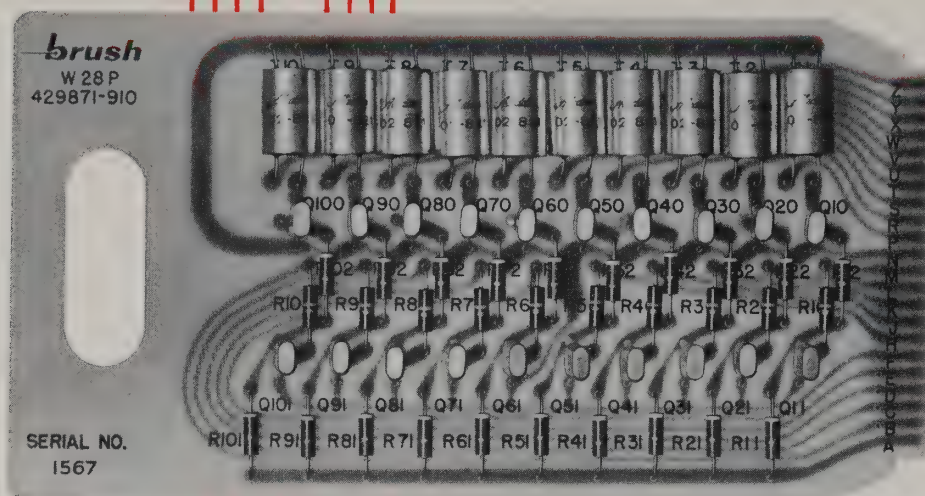
Selection of model depends on whether positive or negative signals are to be monitored.

SPECIFICATIONS

- Capacity** Accommodates up to 12 decade boards (120 channels) plus power supply
- Power requirement** Approximately 20 watts (with all channels operating), 115 volts, 60 cps
- Finish** Same as Operations Monitor



RE 3610 60 Operations Monitor with 120 channel Trans-Switcher



Portable Operations Monitor has provision for internal mounting of three decade boards.

For rack-mounted units, special Trans-Switcher frame accommodates up to 12 boards (120 channels), with internal d-c power supply (see other side of this catalog sheet).

trans-switcher decade boards

solid-state switching circuits for high speed event recording

Brush Trans-Switcher decade boards permit the user to take full advantage of the fast response and high resolution inherent in the Brush Operations Monitor. Each board contains ten transistor circuits which instantly switch signals to the Operations Monitor styli and display their presence (or absence) on a time-regulated moving chart. Response is less than 2 milliseconds. Mechanical delays, contact bounce and other ambiguities are eliminated.

Power requirements are 1/100th that of conventional relays, typically about 20 milliwatts per circuit.

Decade boards are available for either positive or negative inputs, and for several modes of operation, tabulated below.

Features:

- Reliability** A solid state device; no mechanical or moving parts to wear or fail.
- Rapid Response** Less than 100 microseconds to respond to change of signal condition.
- Large Capacity** Up to 120 separate trans-switching channels contained within a standard panel-mounted unit only 5 1/4" high.
- High Input Impedance** Minimum disturbance to signal source.
- Flexibility** Decade boards may be interchanged to provide for different types of signals; different modes of operation extend applicability of complete system.

Ordering Code	Number of Sources Monitored	Switching Type	Operating Voltage Range (3)	Signal Polarity (1)	Input Resistance
W28P	10	SPST	20 to 60V dc	Positive	27K
W28N	10	SPST	20 to 60V dc	Negative	27K
W12P	10	SPST	2 to 20V dc	Positive	4K
W12N	10	SPST	2 to 20V dc	Negative	4K
T28P	5	SPDT (2)	20 to 40V dc	Positive	3K
T28N	5	SPDT (2)	20 to 40V dc	Negative	3K
T12P	5	SPDT (2)	5 to 20V dc	Positive	1.5K
T12N	5	SPDT (2)	5 to 20V dc	Negative	1.5K
R	10				

Substitutes for decade board where external switching or relays are used.

Note 1: All decade boards for use in a single Trans-Switcher frame must be of a single polarity with chassis ground — either positive or negative. Proper power supply must be specified.

Note 2: Two adjacent styli are used to display change of signal condition; one being considered the "on" channel, the adjacent one the "off" channel. Either the presence or absence of signals on both channels of a pair simultaneously is positive indication of circuit failure somewhere; hence, this is fail-safe presentation.

Note 3: The Trans-Switcher is a current sensitive circuit and requires about 500 micro-amperes for switching. Voltage range as given assumes source impedance up to 3000 ohms. All channels will switch at the minimum voltage indicated; however, individual channels may switch on voltages lower than specified.

FOR APPLICATION ASSISTANCE, CONTACT YOUR BRUSH FACTORY BRANCH OR ENGINEERING REPRESENTATIVE

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CORPORATION

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SECTION V

MAINTENANCE

This amplifier has been balanced and adjusted accurately before shipment from the factory, and should give long, trouble-free service. For any servicing other than that described in this manual, the instrument should be sent to one of the Brush service facilities (listed on the Warranty page), where it can be restored to original condition. See shipping instructions following the Table of Contents.

TUBE REPLACEMENT

To replace any faulty tube, begin by disconnecting the power cable. If the amplifier is mounted in a portable case, remove the screws on the top and bottom of the case, as well as the mounting screws on the front panel, and withdraw the amplifier. If the amplifier is mounted in a rack, remove from the rack and remove the top portion of the wrap-around cover. In either case, all tubes may be identified as shown in Figures 11 and 12.

SIDE CHASSIS

When a tube has been replaced in either side chassis of the amplifier, that amplifier channel must again be balanced and calibrated. Balancing and calibrating procedures are repeated below:

1. See that the amplifier and oscillograph are disconnected from their power source, and that power switches of the amplifier and oscillograph are in "off" position. Connect the OUTPUT connector of the amplifier (Fig. 1) with the oscillograph input connector by means of the amplifier-to-oscillograph signal cable.

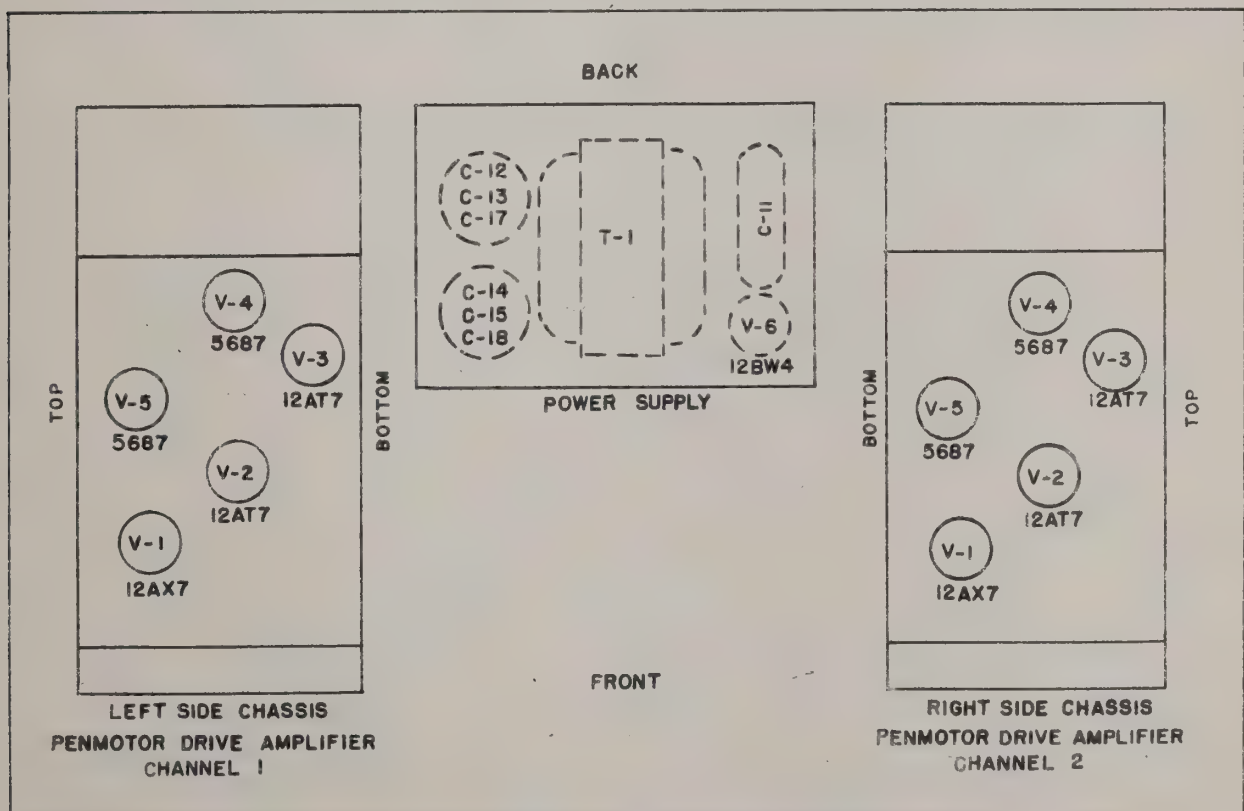


Fig. 11. Tube Layout—Dual Channel D.C. Amplifier Model RD 5621 00.

2. Turn both VOLTS/CHART LINE switches (Fig. 2) to "off". Connect the amplifier and oscillograph to their power source, and turn the amplifier POWER switch (Fig. 2) to "on". Allow 15 minutes for the amplifier to warm up.
3. Turn the oscillograph "on" at slow chart paper speed (to conserve chart paper).
4. Set the INPUT switch (Fig. 2) in the "balanced" position.
5. Turn the CALIBRATION control (Fig. 2) full clockwise, and bring the oscillograph pen approximately to chart center by means of the B (BALANCE) control (Fig. 2).
6. Turn the A (BALANCE) control (Fig. 2) to its extreme counterclockwise position. Rapidly rotate the CALIBRATION control (Fig. 2), counterclockwise, then clockwise, while turning the A (BALANCE) control slowly clockwise until no pen deflection is noted.
7. Center the pen on the chart by means of the B (BALANCE) control (Fig. 2).
8. Turn the VOLTS/CHART LINE switch (Fig. 2) to the "calibrate" position and adjust the CALIBRATION control (Fig. 2) as necessary to obtain a pen deflection of 20 chart lines. Turn the VOLTS/CHART LINE switch to "off".
9. Check 20 line deflection by turning the VOLTS/CHART LINE switch (Fig. 2) to the "calibrate" position. If necessary, readjust the CALIBRATION control (Fig. 2) to obtain a pen deflection of 20 chart lines.

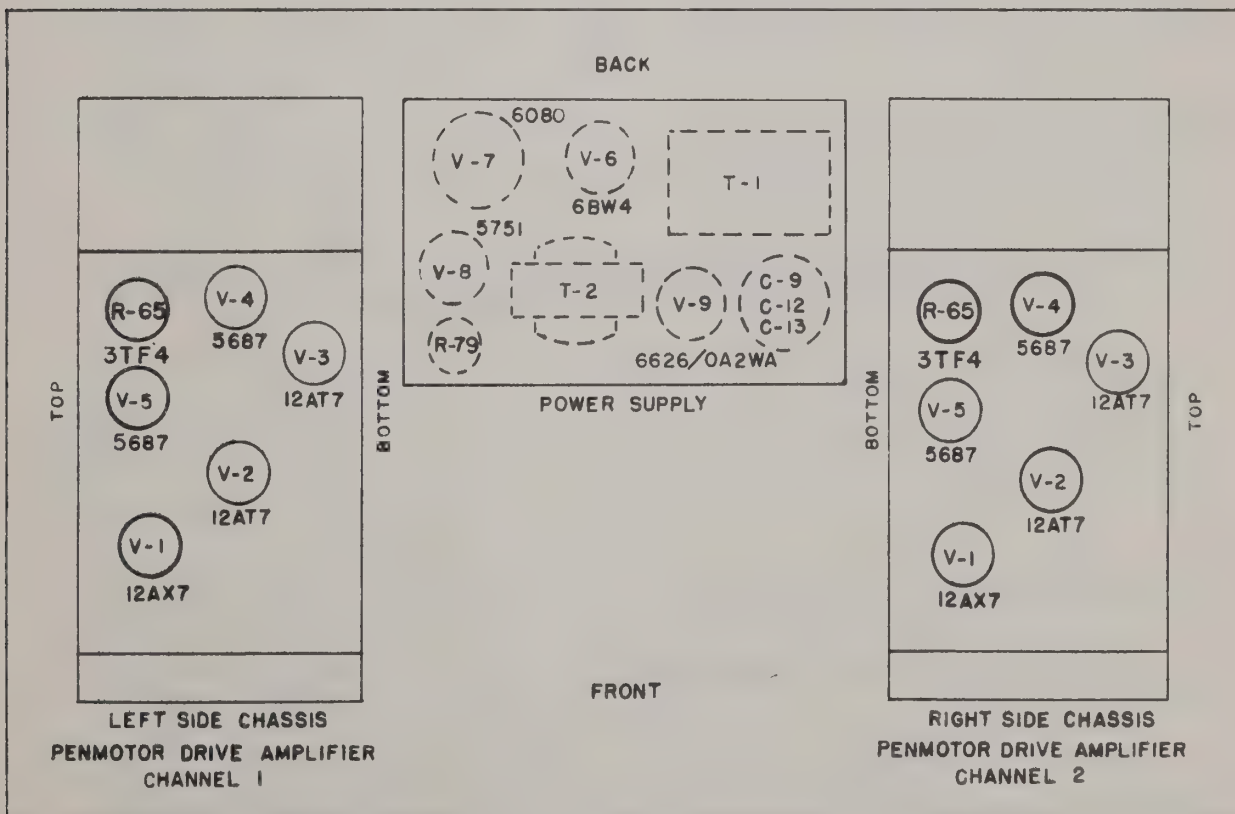


Fig. 12. Tube Layout—Dual Channel D.C. Amplifiers Models RD 5621 01 and RD 5621 02.

10. Turn the INPUT switch (Fig. 2) to the "grounded" position to accommodate a single-ended input signal, or to the "balanced" position to accommodate a balanced input signal.

If the INPUT switch is in the "grounded" position, center the pen on the chart paper by means of the PEN BIAS control (Fig. 2).

POWER SUPPLY CHASSIS

No adjustment is required following the replacement of the 12BW4 tube (V-6) in the power supply chassis of the Model RD 5621 00 (Fig. 11).

Following the replacement of any tube in the power supply chassis of Model RD 5621 01 or Model RD 5621 02, (Fig. 12), adjust the +B voltage to 235 volts by means of the potentiometer control R-79 (measured from the junction of C-10 and R-80 to pin 5 of the 6626/OA2WA tube (V-9)).

Following any tube replacement, install the amplifier in its portable case or, if the amplifier is to be rack-mounted, replace the top portion of the wrap-around cover and install the amplifier in the rack.

ADJUSTMENT OF HUM BALANCE CONTROL

To adjust the hum balance control on the power supply for optimum amplifier operation, proceed as follows:

1. Connect a.c. output meters to the outputs of the amplifier channels. If d.c. blocking condensers are not included in the output meters, install such condensers in the meter-amplifier circuits.
2. With no signal applied to either channel, and with the VOLTS/CHART LINE switches (Fig. 2) in "off" position, operate the amplifier and adjust the hum balance control as necessary to produce the lowest simultaneously indicated hum levels in the two channels.

MODIFICATION OF POWER TRANSFORMER CONNECTIONS FOR OPERATION AT 95 TO 115 VOLTS

The Brush Dual Channel D.C. Amplifiers Models RD 5621 01 and RD 5621 02 are normally wired to operate on a power line voltage of from 105 to 125 volts. If the available power source is from 95 to 115 volts, a slight modification in the wiring of the power transformers (T-1) will adapt either amplifier to operation from such a power source. To make this modification, proceed as follows:

1. Disconnect the input power lead and capacitor lead from terminal "3" of the power transformer (T-1). Connect these two leads to terminal "2" of the power transformer. Refer to the Tube Layout (Fig. 12), and to the Schematic Diagram.
2. Re-solder to terminal "3" of the power transformer (T-1) that lead connecting terminal "3" to the separate filament transformer (T-2).

The above modification will be made at the factory if requested at time of ordering.

The Dual Channel D.C. Amplifier Model RD 5621 00 will operate only on a power line voltage of 105 to 125 volts, 60 cps.

TROUBLE SHOOTING

The chart below lists symptoms and probable causes of improper operation of the amplifier, or failure of the amplifier to operate, as well as probable remedies for unsatisfactory operating conditions. The conditions described in the chart are for a Dual Channel D.C. Amplifier Model RD 5621 00, RD 5621 01 or RD 5621 02, connected to a correctly adjusted, operating Brush oscillograph, and operating from a 60 cps 115 volt power source. Procedures suggested in the "Remedy" column may be performed by operating personnel.

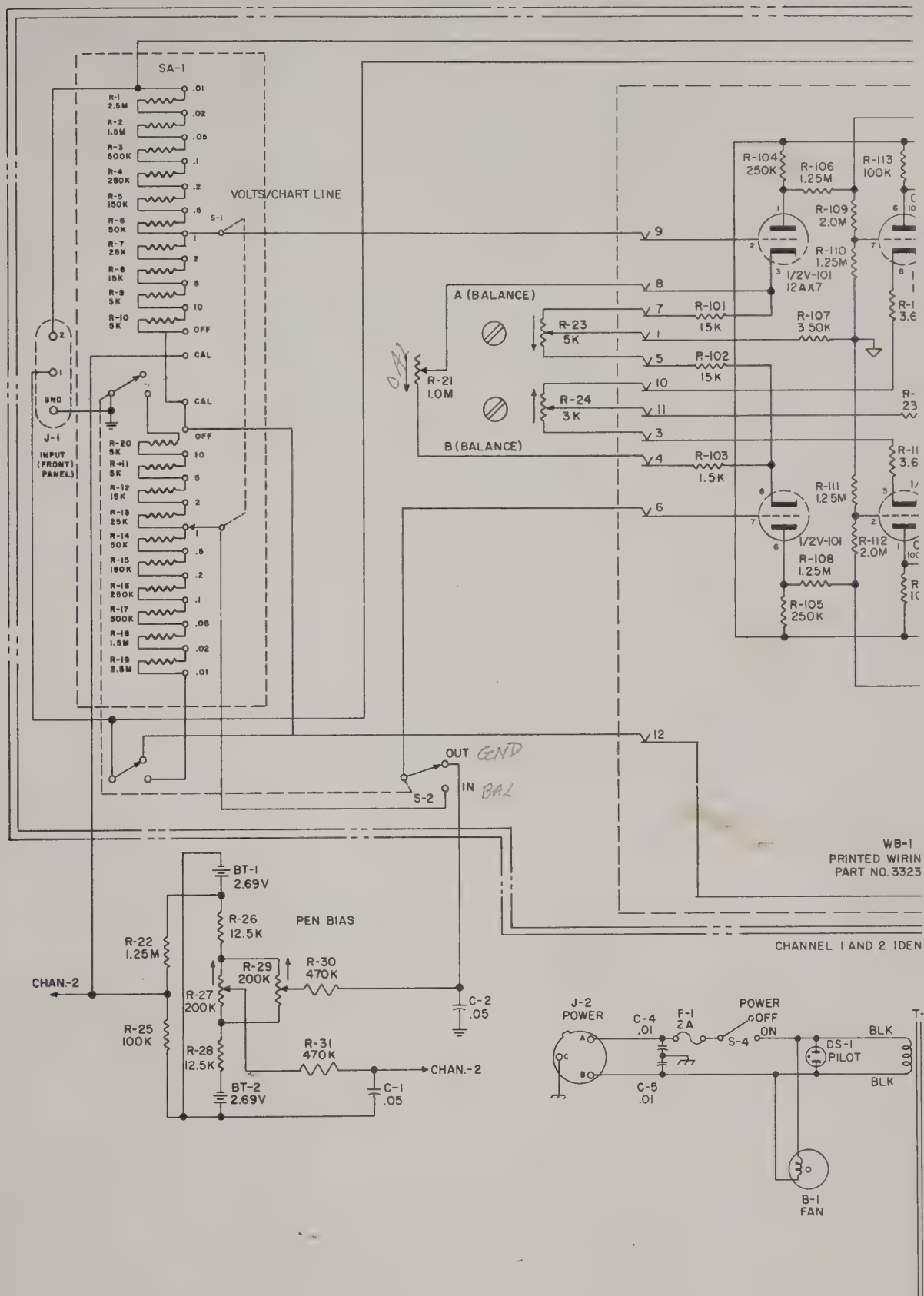
SYMPTOM	CAUSE	REMEDY
1. Amplifier does not operate; pilot lamp does not light.	a. Power cable disconnected. b. No power line voltage. c. Fuse open.	a. Connect power cable. b. Connect to proper power source. c. Replace fuse.
2. Amplifier does not operate; pilot lamp lights.	a. Rectifier tube (12BW4 or 6BW4) defective. b. Cabling to oscillograph defective. c. Defective 6080 tube.**, *** d. Defective 4HTF4 ballast resistor.***	a. Replace tube. b. Repair cable. c. Replace tube. d. Replace defective ballast resistor.
3. Amplifier operates, and can be balanced; noise or hum indicated on chart.	a. Open resistor from +B or -B to center tap of heater winding. b. Open capacitor from chassis to center tap of heater winding.** c. Lack of shielding at input.*, ** d. Defective 12AX7, 12AT7, or 5687 tube (cathode to heater leakage). e. Defective filter capacitor.**, *** f. Unregulated plate voltage.**, *** g. Hum balance control not adjusted properly.	a. Replace defective resistor. b. Replace defective capacitor. c. Shield input terminals. d. Replace defective tubes, balance and calibrate amplifier. e. See item 11, below. f. See item 11, below. g. Refer to "Adjustment of Hum Balance Control," above.
4. Amplifier operates, and can be balanced; drifts excessively (more than 1/2 mm/hr. for Models RD 5621 00 and RD 5621 01, more than 1/10 mm/hr. for the Model RD 5621 02).	a. Power line voltage below 105v or above 125v. b. Defective 12AX7 or 12AT7 tubes. c. +B to -B voltage varies.**, *** d. Power line frequency variation from 60 cps greater than 1/2 cps.*	a. Connect amplifier to proper power source. b. Replace defective tubes, balance and calibrate amplifier. c. See item 11, below. d. Connect amplifier to proper power source.

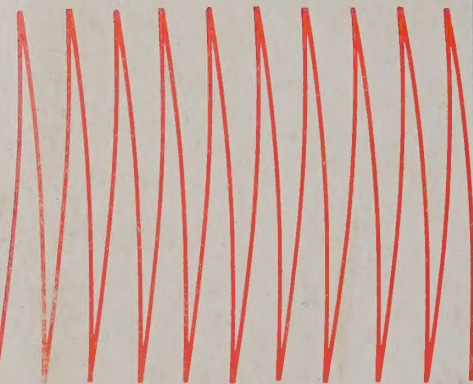
SYMPTOM	CAUSE	REMEDY
5. Amplifier operates, and can be balanced; PEN BIAS control does not operate.	a. Defective mercury cell.*,** b. Defective contact on mercury cell holder.*,** c. INPUT switch in "balanced" position. d. Defective PEN BIAS control. e. Shorted capacitor in PEN BIAS control arm circuit. f. Open voltage divider resistor.***	a. Replace mercury cell. b. Clean contact. c. Set INPUT switch in "grounded" position. d. Replace control. e. Replace defective capacitor. f. Replace defective resistor.
6. Maximum calibration less than 20 chart lines.	a. Defective contact on mercury cell holder. b. Defective mercury cell. c. Power line voltage below 105v. d. Weak 12AX7, 12AT7, or 5687 tubes. e. Resistance of CALIBRATION control too high. f. Power line frequency variation from 60 cps greater than 1/2 cps.	a. Clean contact. b. Replace mercury cell. c. Connect amplifier to proper power source. d. Replace weak tubes, balance and calibrate amplifier. e. Replace CALIBRATION control. f. Connect amplifier to proper power source.
7. Amplifier can be balanced and calibrated, but is non-linear.	a. Defective 12AX7, 12AT7, or 5687 tubes.	a. Replace defective tubes, balance and calibrate amplifier
8. Amplifier cannot be frequency compensated.	a. Improper compensation procedure. b. Resistor or capacitor of wrong value in pen compensation network.	a. Refer to "Frequency Compensation," above. b. Replace defective resistor or capacitor.
9. Cross talk between penmotors.	a. Penmotor-oscillograph circuit grounded.	a. Disconnect oscillograph and check for grounds.
10. Calibration signal deflects pen to right side of chart paper.	a. Calibration cells improperly installed in cell holders.	a. Install cells in holders with negative (—) side toward front panel of amplifier.
11. +B to —B regulated voltage is erratic.**, ***	a. Insufficient power line voltage. b. Defective 6BW4, 6080, 5751 or 6626/OA2WA tube. c. Inoperative filter capacitor. d. Defective resistor or capacitor.	a. Connect amplifier to proper power source. b. Replace defective tube. c. Replace defective capacitor. d. Replace defective resistor or capacitor.

* Applicable to Model RD 5621 00.

** Applicable to Model RD 5621 01.

*** Applicable to Model RD 5621 02.





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